Int. Zoo Yb. (1986) 24/25: 77–99

An historical overview of selected rare ruminants in captivity

WARREN D. THOMAS¹, ROBERT BARNES², MICHAEL CROTTY³ & MARVIN JONES⁴

¹Director, ²Principal Animal Keeper, ³Curator, Los Angeles Zoo, 5333 Zoo Drive, Los Angeles, CA 90027 and ⁴Registrar, San Diego Zoo, Balboa Park, POB 551, San Diego, CA 92112, USA

Ruminants have always been a major part of most general zoological collections. They tend to occupy the largest portion of a zoological park primarily because of their spatial needs. Their variations in size, from quite small to very large, allows the zoo to display them in a wide range of exhibits, from small, box-like stalls to immense park-like settings often in mixed groupings. Their diversity, which ranges from the bizarre to the beautiful, gives them a strong appeal for the public.

From an economic standpoint, they are often the mainstay of the zoo's finances; the sales and exchanges of surplus stock can often make the animal collection self-supporting and, as many ungulates have relatively rapid reproductive rates and a reasonable longevity, there can be a substantial monetary return from surplus offspring.

In the two decades (1962–1982) covered by this survey, a great many animals have been imported from the wild. Many groups have flourished and now represent self-sustaining captive populations; others have barely maintained their numbers and still others have a very poor record. Some of the reasons, both positive and negative, are possible to quantify; others are much more difficult to assess.

Certain general observations can be made. It goes without saying that the larger the founder group the better the chance of a captive population becoming established. The temperament of the animals is a major consideration. A highly nervous individual is more difficult to establish than a calm one. Almost as a rule of thumb, the larger species tend to be less complicated than smaller ones; this generalisation is particularly applicable to the antelope and wild cattle. Another contributing factor in the success of any captive

population is its pattern of distribution. There are examples of wild stock brought into captivity in substantial numbers but concentrated mainly or entirely in a single collection. While this has the obvious advantage that a good group size allows management to combine and recombine individuals in a planned breeding programme, from a disease standpoint it is always risky. Once an epidemic strikes, it can easily destroy an entire population.

Underlying all these considerations is the basic management of the animal once it reaches the captive environment. In some cases, relatively small original groups have blossomed and flourished; in others, even where substantial numbers have been brought in, we have failed to meet the needs of the animals and our attempt to establish them in captivity has not been a success. All too often in the past greater co-operation amongst zoos might have made a measurable difference as to whether the breeding programme succeeded or failed. Much of this earlier failure to work together, both in terms of the sharing of information and the management of the species as a total captive population, has been either moderated or eliminated. Co-operation is at an all-time high and recent successes with a number of species reflect that fact.

One other important consideration, especially relevant when only a very small number of a species is imported, is what we may call 'the luck of the draw'. When we acquire animals from the wild, it is usually impossible to be at the collecting site and exercise our own judgement on those specimens which would be the most suitable for our needs. The reality is that we must take what is available and have no idea of the

particular animal's temperament or character until after it arrives. In addition, although the phenotype of the imported animals can be assessed, we can have no idea of their genotype. We may, for example, import two ♂♂ and two ♀♀ which in appearance are much alike, but we do not know whether they are related or unrelated. We know nothing of their characters or breeding potential. Only after they have been in the collection for a period of time can these be determined and only after successive generations and with the full co-operation of all zoos can comprehensive studbook records be formulated and maintained.

This survey of some of the most important and interesting ungulate species was based on data received in response to a questionnaire (Appendix 1) covering the history of each species in the collection, including its reproductive background, nutrition, behaviour, management and veterinary history. Of the 92 zoos circulated, 49 supplied information (Appendix 2).

The species mentioned in this paper for which population census figures have been collected by the *International zoo yearbook* during the last 20 years or so are listed in Table 1. Where appropriate the current IUCN *Red data book* category is shown (Goodwin & Holloway, 1978; Thornback & Jenkins, 1982); species in the census which are not currently listed by IUCN have either been so at some time during the last two decades or are included because they are categorised as 'rare in zoos'. When assessing the figures in Table 1, it is important to bear in mind that they represent the state of the collections which contributed data for publication in that particular year. The totals given, especially for the smaller populations, can be greatly affected by the omission of one or two important holders. Another factor is that the inclusion of zoos which are situated within the animals' natural range and have easy access to new specimens without breeding them may give an unduly optimistic picture. This has been true of the chevrotains in some southeast Asian zoos and the brockets in some South American zoos. The general impressions which can be drawn from Table 1,

however, are in our assessment borne out by the study of the full annual data and the results of our own survey.

The species reviewed below are arranged in taxonomic order as currently in use in the *Yearbook's* reference section.

CHEVROTAINS

We received data on two species of *Tragulus*, the Lesser Malay chevrotain *T. javanicus* and the Larger Malay chevrotain *T. napu* (Table 1); the third species, the Indian chevrotain *T. meminna* is also recorded as being bred in captivity in small numbers. All are rare in zoos. The chevrotains are nervous, shy, retiring animals whose natural habitat is the dense vegetation of the rainforest and monsoon forests of southeast Asia. In captivity their fortunes have fluctuated. A number have been brought into Asian and European zoos but increases have more often been the result of the influx of new animals from the wild than of sustained breeding.

An exception is the history of the Larger Malay chevrotain in the United States. Since World War II there has been a single importation which consisted of either 1.2 or 1.3 animals, from which a breeding group has been built up and maintained at the New York Bronx Zoo for many years. Although the mortality rate has been high, the breeding rate is sufficient to keep the population at a surprisingly high level.

Pairs have been sent, from time to time, to other zoos, but have never really flourished. The answer to the problem may lie, at least in part, in the methods of housing. New York keeps them in isolation in relatively small quarters with a minimal amount of stress and outside contact. Elsewhere they have often been placed in larger displays which were more exposed to the public. It can be hypothesised that these animals may require more seclusion and sense of security than they are often allowed.

DEER

We looked at three representative groups in the family Cervidae, the Chinese water deer *Hydropotes inermis*, four Asiatic forms of the widespread Eurasian subfamily Cervinae and

five species of New World deer. In general the larger deer seem to be thriving with self-sustaining populations but the position of the smaller more delicate species is less satisfactory and more attention needs to be given to them.

An exception in the latter group is the Chinese water deer, an unusual small deer which, as long as its idiosyncracies are understood, will adapt well to captivity. Some herds have become so firmly established in a number of parks in Great Britain that they are almost considered an introduced native form. The free-living herd at Whipsnade Park, for example, produced 50 young in 1982 and 166 in 1983. The difficulty of maintaining them in other types of collections lies in the fact that they tend to be highly nervous animals which need a great deal of room. Their automatic flight reaction can be disastrous if their quarters are small. A further problem in establishing them in North America, where they were imported in only small numbers, was the tendency for more ♂♂ than ♀♀ to be born.

Once their spatial needs are satisfied, the animals have done well. The ♂♂ seem to be quite tolerant of each other as long as they have sufficient space and they can be successfully exhibited with a variety of larger forms. At Los Angeles we keep them with a herd of Père David's deer *Elaphurus davidianus* in an enclosure of about 2000 m².

The four forms of large Asian deer we considered are the Barasingha *Cervus duvauceli*, the Formosan sika *C. nippon taiouanus*, the Indochina sika *C. n. pseudaxis* and the Burma brow-antlered deer *C. eldi thamin*. All are found in open monsoon forest, generally in areas of fairly dense human population, and they have suffered loss of habitat and persecution by man. Although *C. n. pseudaxis* and *C. eldi thamin* are not currently listed by IUCN as threatened, other subspecies of the same taxon are.

Given a sufficiently large founder group, all do reasonably well in captivity and management is relatively uncomplicated. Their reproductive level is high. Although most of the breeding herds now consist of captive-born animals, neonatal mortality is not unduly

large and their numbers continue to increase. Both the Barasingha and Formosan sika appear to be well established. Although the Indochina sika and the Burma brow-antlered deer are found in fewer collections, both subspecies show a steady increase overall (Table 1). The figures for the sika might well be higher but the subspecific status of many of those reported is either unknown or doubtful; many are almost certainly subspecific hybrids.

It is of interest to record that the Barasingha reproduced extraordinarily well for several generations from an extremely small gene pool, viz. a single ♂ and two ♀♀ which were acquired by a private ranch in southern Oklahoma in the early 1930's. With little or no management and in a somewhat wild setting, the herd increased to over 100 animals by 1963. The major causes of neonatal mortality were inclement weather which affected young born early in the season and predation by Coyotes *Canis latrans*, Bobcats *Felis rufus* and wild domestic dogs.

The five species of American deer included in the survey are all smaller forms and none is really well established in captivity. The Marsh deer *Blastocerus dichotomus* and the Pampas deer *Ozotoceros bezoarticus* (Table 1) both come from the southern third of South America and are found in open brush country. Apart from presumed wild-caught specimens in zoos in their local range, the Marsh deer have been represented in recent years only by captive-bred specimens in two German zoos (West Berlin and Krefeld). By the beginning of 1982 only three ♂♂ survived from the original breeding groups in Germany and there were no breeding pairs recorded in the South American zoos.

Pampas deer are also kept in small numbers in Europe and South America and again only in West Berlin and Krefeld has there been any consistently successful breeding. The very latest census figures, however, do offer a slightly more hopeful picture with a pair at San Diego and a substantial number, some of which are captive bred, newly reported from Piriapolis, Uruguay.

The Chilean pudu *Pudu pudu* has also been available in only small numbers and, although

Source: Vol:	3 1962	7 1966	11 1970	15 1974	19 1978	22 1981	23 1982
ay chevrotain <i>javanicus</i>		5.6.13 (2.2.3) <u>5</u>	6.8 (3.5) <u>3</u>	21.32.2 (7.10.2) <u>10</u>	31.49.1 (13.23) <u>10</u>	27.44.13 (15.31.5) <u>10</u>	18.27 (11.16) <u>6</u>
ay chevrotain <i>napu</i>		11.19.1 (7.13.1) <u>4</u>	23.28 (18.21.3) <u>7</u>	15.26.1 (14.24.1) <u>4</u>	15.16 (13.11) <u>6</u>	13.20 (most) <u>6</u>	13.16 (all) <u>4</u>
ump deer or Barasingha <i>uwauceli</i> IUCN (E)			34.54.11 + (20.42.10) <u>20</u>	57.86.6 (53.82.6) <u>26</u>	85.125.5 (81.124.5) <u>27</u>	114.175.2 (most) <u>29</u>	121.17 (most) <u>27</u>
ow-antlered deer <i>di thamin</i>	7.6 (1.1.3) <u>2</u>	6.3 <u>3</u>	15.11 (2.1) <u>5</u>	31.34 (11.16) <u>6</u>	39.50 (29.34) <u>9</u>	47.48.6 (most) <u>9</u>	58.62 (most) <u>10</u>
sika <i>ippon pseudaxis</i>				3.13 (3.13) <u>2</u>	12.23 (12.23) <u>6</u>	24.29 (most) <u>8</u>	21.35.3 (most) <u>11</u>
ormosan sika <i>uanus</i> IUCN (E)		60.120.80 (41.90.78) <u>32</u>	89.201.249 (78.184.99) <u>24</u>	no census taken between 1973–1979 inclusive		119.180.13 (most) <u>16</u>	116.19 (most) <u>19</u>
<i>us dichotomus</i> IUCN (V)			2.1 <u>1</u>	4.4 (0.1) <u>2</u>	1.2 (1.1) <u>2</u>	3.3 (3.1) <u>3</u>	4.1 (3.0) <u>4</u>
deer <i>os bezoarticus</i>		0.1 <u>1</u>	3.1 (1.0) <u>1</u>	2.2 <u>2</u>	9.9 (4.4) <u>5</u>	12.10 (7.2) <u>7</u>	10.14 (7.6) <u>8</u>

	Source: Vol:	3	7	11	15	19	22	23
		1962	1966	1970	1974	1978	1981	1982
udu		0.1 +	1.4	5.9	15.18	16.14	16.16	22.24
du		<u>2</u>	<u>3</u>	<u>(1.3)</u> 5	<u>(6.7)</u> 8	<u>(11.8)</u> 8	<u>(15.14)</u> 5	<u>(19.19)</u> 6
ohnstoni		20.19 <u>(5.2)</u> 16	29.24 <u>(13.12)</u> 18	28.22 <u>(16.15)</u> 18	29.24 <u>(21.20)</u> 18	28.32 <u>(25.27)</u> 14	23.28 <u>(most)</u> 12	26.29 <u>(most)</u> 13
bra americana					30.39.8 <u>(12.17.8)</u> 21	28.44 <u>(12.21)</u> 15	28.38 <u>(most)</u> 14	28.35 <u>(most)</u> 14
hus angasi		12.14 <u>(10.9)</u> 4	17.16.11 <u>(13.11.2)</u> 10	42.52 <u>(28.24)</u> 16	79.136.6 <u>(60.88.6 +)</u> 26	98.156.6 <u>(77.102 +)</u> 39	105.154.3 <u>(most)</u> 38	113.17 <u>(most)</u> 38
hus euryceros		1.1 <u>2</u>	2.1 <u>2</u>	4.7 <u>4</u>	14.18 <u>(2.4)</u> 12	25.44 <u>(10.19)</u> 19	39.56 <u>(23.31)</u> 21	38.58 <u>(27.36)</u> 19
erby eland gus derbianus				4.9 <u>(1.2)</u> 3	8.10 <u>(3.3)</u> 6	6.5 <u>(3.2)</u> 3	7.7 <u>(6.7)</u> 2	6.5 <u>(5.5)</u> 2
eland anoa lepressicornis IUCN (E)							13.13 <u>(8.10)</u> 8	16.13 <u>(12.11)</u> 8
noa uarlesi IUCN (E)			11.9 <u>(8.8)</u> 9	10.8 <u>(5.3)</u> 9	20.14 <u>(5.2)</u> 12	20.12 <u>(8.8)</u> 13	7.5 <u>(2.5)</u> 5	3.3 <u>(1.3)</u> 3

Source: Vol:	3 1962	7 1966	11 1970	15 1974	19 1978	22 1981	23 1982
us IUCN(V)	1.2 (1.1) <u>1</u>	9.10 (3.3) <u>10</u>	8.16+ (6.11) <u>7</u>	22.37 (17.24) <u>14</u>	31.46 (28.36+) <u>18</u>	41.42 (most) <u>17</u>	50.72 (most) <u>20</u>
nicus IUCN(V)	9.7.2 (4.3) <u>6</u>	32.43+ (18.28.1) <u>23</u>	36.60.4 (30.54) <u>22</u>	73.96 (63.88) <u>32</u>	83.107 (79.99+) <u>36</u>	76.106 (most) <u>30</u>	61.99 (most) <u>30</u>
duiker <i>phus jentinki</i> IUCN(E)			1.2 <u>1</u>	0.1 (0.1) <u>1</u>	2.2 (1.2) <u>1</u>	1.1 (0.1) <u>1</u>	1.3 (0.2) <u>2</u>
ked duiker <i>phus sylvicultor</i>	2.2 (1.1) <u>1</u>	4.4 (2.0) <u>4</u>	7.6 (1.1) <u>4</u>	10.8 (5.3) <u>5</u>	19.12 (11.4) <u>9</u>	18.14 (most) <u>12</u>	15.15 (most) <u>11</u>
Zebra duiker <i>phus zebra</i>	0.2 <u>1</u>	3.3 <u>2</u>	1.0 <u>1</u>	2.2 (1.0) <u>2</u>	7.2 (2.0) <u>5</u>	4.5 (1.2) <u>4</u>	5.6 (2.1) <u>4</u>
ope <i>gus equinus</i>	1.0 <u>1</u>	1.1 <u>2</u>	7.13 (3.2) <u>4</u>	41.62 (26.28+) <u>19</u>	56.90 (47.64) <u>22</u>	41.68 (most) <u>23</u>	61.92 (most) <u>30</u>
orned oryx <i>mmah</i> IUCN(V)	7.11 (5.7) <u>6</u>	12.10 (11.5) <u>9</u>	58.67 (42.31) <u>23</u>	96.140.2 (84.115.2) <u>32</u>	139.206.3 (119.169.3+) <u>37</u>	176.295.40 (most) <u>42</u>	179.39 (most) <u>50</u>
oryx <i>coryx</i> IUCN(E)	3.2 <u>3</u>	23.16+ (0.1.9) <u>5</u>	13.15.30+ (8.10) <u>4</u>	35.31 (30.26) <u>5</u>	56.66 (52.62) <u>6</u>	78.79.4 (most) <u>11</u>	67.74 (most) <u>11</u>

Source: Vol:	3	7	11	15	19	22	23
	1962	1966	1970	1974	1978	1981	1982
<i>asomaculatus</i> IUCN(V)	10.10 (3.6) <u>8</u>	22.33 (16.16) <u>18</u>	56.70 (38.43) <u>24</u>	90.125 (74.104.1+) <u>36</u>	130.218.3 (121.203.2) <u>38</u>	149.275.5 (most) <u>44</u>	113.27 (most) <u>46</u>
<i>cus d. dorcus</i>			c.11.17 (1.1) <u>7</u>	20.32 (3.10) <u>12</u>	31.52 (21.29) <u>15</u>	30.53.4 (22.40.4) <u>16</u>	33.59 (26.43) <u>17</u>
ntelope <i>cus hunteri</i> IUCN(R)				3.4 (1.1) <u>1</u>	6.9 (4.5) <u>2</u>	8.9 (2.2) <u>4</u>	6.7 (4.2) <u>3</u>
er <i>cus oreotragus</i>	1.3 <u>1</u>	14.20 (4.8) <u>9</u>	13.26+ (4.13) <u>13</u>	18.18 (14.13) <u>8</u>	12.16 (10.10) <u>8</u>	16.16 (most) <u>5</u>	15.16 (most) <u>5</u>
<i>ourebi</i>	3.3 (1.0) <u>2</u>	13.7.3 (5.1) <u>7</u>	17.18 (8.10.3) <u>9</u>	11.9 (5.4) <u>8</u>	13.10.2 (9.8.2) <u>6</u>	10.8 (8.5) <u>6</u>	9.9 (4.7) <u>6</u>
<i>us moschatus</i>			7.5 (6.3) <u>3</u>	6.7 (5.5) <u>3</u>	10.28 (6.18) <u>5</u>	24.47 (20.32) <u>8</u>	14.20 (12.18) <u>6</u>
<i>us walleri</i>	2.3 (1.5) <u>1</u>	6.6 (3.3) <u>3</u>	2.5 (0.4) <u>3</u>	2.1 (1.1) <u>2</u>	8.9 (1.1) <u>4</u>	16.25 (6.9+) <u>5</u>	21.23 (15.15) <u>5</u>
lle <i>dama</i>			10.23 (7.10) <u>3</u>	23.46 (20.39) <u>11</u>	48.74 (45.72) <u>16</u>	68.110 (most) <u>22</u>	70.13 (most) <u>20</u>

Source: Vol:	3	7	11	15	19	22	23
	1962	1966	1970	1974	1978	1981	1982
zelle <i>a arabica</i>		5.6.9+ (0.2.5) <u>8</u>	17.31+ (7.11) <u>11</u>	40.65.1 (30.44.1+) <u>12</u>	21.56.10 (17.47.8) <u>9</u>	26.41.12 (most) <u>11</u>	25.50. (most) <u>11</u>
orned gazelle <i>leptoceros</i> IUCN(E.)		2.1 (1.0) <u>1</u>	6.7 (4.1) <u>3</u>	8.19 (7.18) <u>4</u>	13.16 (10.16) <u>2</u>	27.25 (all) <u>2</u>	21.23 (all) <u>4</u>
zelle <i>pepei</i> IUCN(I)					8.15 (8.13) <u>3</u>	7.17 (7.16) <u>2</u>	8.17 (8.16) <u>3</u>
<i>arica</i>	4.7 <u>5</u>	4.10 (3.3) <u>5</u>	7.13+ (4.4) <u>6</u>	13.25 (6.8) <u>12</u>	14.32 (3.3) <u>12</u>	23.49.38 (18.32.2+) <u>10</u>	37.67. (21.34.) <u>10</u>
erow <i>nis c. crispus</i>	2.1 <u>1</u>	7.10.1 (1.3.1) <u>5</u>	c.13.11 (5.3.2) <u>6</u>	37.36 (19.17) <u>14</u>	39.44.2 (25.18.2) <u>21</u>	46.51 (27.17) <u>25</u>	51.49. (27.21.) <u>28</u>
ntain goat <i>s americanus</i>		8.9 (2.4) <u>4</u>	11.18 (4.10) <u>9</u>	14.15 (8.12) <u>11</u>	19.22 (16.18) <u>11</u>	21.34.4 (most) <u>14</u>	29.47. (most) <u>16</u>
in <i>t. taxicolor</i>	1.2 <u>2</u>	2.3 <u>3</u>	2.4 (0.1) <u>2</u>	4.4 (1.0) <u>3</u>	6.6 (1.0) <u>5</u>	4.3 (3.1) <u>3</u>	4.3 (3.2) <u>3</u>
<i>us hyllocrius</i> IUCN(V)		4.4 (4.3) <u>2</u>	7.5 (7.4) <u>2</u>	2.2 (2.1) <u>2</u>	7.7 (6.4) <u>2</u>	13.12 (12.8) <u>4</u>	17.22 (most) <u>5</u>

Source: Vol: 3		7	11	15	19	22	23
		1966	1970	1974	1978	1981	1982
Wild goat or Bezoar <i>Capra aegagrus</i>		6.9.3+ (2.3) 10	21.38.4 (18.31.4) 8	11.10 (10. 9) 4	13.17 (11.14) 7	8.8 (7.7) 3	15.14 (14.11) 5
Cretan wild goat <i>C. a. cretica</i>				5.4.4 (4.4.4) 1	16.16.2 (16.16.2) 3	20.22 (14.13+) 3	23.24.1 (14.12+) 4
Pasang <i>C. a. blythi</i>		3.4+ (1.2) 2	3.5 (1.2) 3	6.3 (2.1) 2	4.1 (3.1) 3	2.0 (1.0) 1	1.0 (1.0) 1
Alpine ibex <i>Capra i. ibex</i>				85.94 (80.88) 21	101.118 (88.108+) 28	92.113.16 (most) 27	93.127.9 (most) 28
Siberian ibex <i>C. i. sibirica</i>	1.1 1	29.36 (8.10.3) 22		62.74 (38.50) 31	52.79 (42.63) 28	55.97 (most) 23	59.82 (most) 26
Nubian ibex <i>C. i. nubiana</i>	1.1+ 1	22.16+ (16.12) 10	25.23.1 18.16.1 10	29.27 (18.16) 9	64.76.3 (31.51.3+) 14	84.97.6 (most) 14	104.111.1 (most) 17
Markhor <i>Capra falconeri</i> IUCN(V)	7.5+ (3.1) 2	29.27+ (10.11) 19	52.55 (36.39) 30	21.25 (16.20) 12	41.43.1 (37.36.1+) 15	35.36 (most) 14	29.42 (most) 13
Kashmir markhor <i>C. f. falconeri</i> (incl. <i>cashmiriensis</i>)					6.7 (6.7) 2	3.8 (all) 1	7.14 (all) 1

Source: Vol:		3	7	11	15	19	22	23
		1962	1966	1970	1974	1978	1981	1982
Turkmenian markhor <i>C. f. heptneri</i>					26.42 (25.38) 20	31.43 (29.40) 23	29.49 (most) 18	30.41 (most) 17
Straight-horned markhor <i>C. f. megaceros</i> (incl. <i>jerdoni</i>) IUCN(E)					6.5 (5.5) 2	6.6 (6.6) 3	11.12 (most) 4	18.19 (all) 5
Bharal or Blue sheep <i>Pseudois nayaur</i>			6.5 (1.0) 5	4.4 (1.2) 3	7.3.8 (3.2+) 5	6.11 (4.5) 5	7.11.2 (most) 5	7.13 (most) 5
American bighorn <i>Ovis canadensis</i> incl. California bighorn <i>O. c. californiana</i>			15.45 (4.12.6) 10	18.46 (7.19) 14	29.51 (19.36) 20	44.54.2 (38.42.2) 23	24.47 (most) 14	25.52 (most) 17
Desert bighorn <i>O. c. nelsoni</i>			1.2 (1.2) 1				5.6 (3.4) 2	5.4 (5.4) 2
Dall sheep <i>Ovis dalli</i>		1.5 (0.2) 1	8.9 (6.4) 2	16.20 (2.5.20) 5	28.55 (16.22) 9	26.46 (21.36) 11	39.80 (most) 16	40.79+ (most) 16
Stone sheep <i>O. d. stonoi</i>			2.11 (1.5) 2	3.13 (0.4) 2	1.1 (1.1) 1	6.5 (5.5) 4	10.14 (all) 4	13.21 (all) 4

Source: Vol:	3 1962	7 1966	11 1970	15 1974	19 1978	22 1981	23 1982
Elburz red sheep <i>Ovis orientalis</i> incl. <i>O. o. orientalis</i>		7.10 (3.5.2) 4	7.16.2 (4.12.2) 4	7.10 (3.7) 5	21.27 (20.26) 5	23.31 (most) 6	30.40 (most) 7
Cyprus red sheep <i>O. o. ophion</i> IUCN (E)			1.6 (0.2) 1		1.3 1	6.7 (3.2) 1	9.9 (some) 1
Afghanistan/Iranian urial <i>O. o. cycloceros</i>			8.6 (1.2) 6	4.8 (1.4) 4	28.31.6 (15.13.5) 8	20.25.2 (most) 6	24.26 (most) 8
a number of other <i>Ovis orientalis</i> spp were recorded at various times giving a species total of:			33.58.2 (13.38.2) 22	23.31 (13.22) 19	71.83.6 (55.60.5) 21	47.66.2 (most) 17	74.110 (most) 20

*indicates studbook in operation;

*(new) indicates approved studbook for which data are being collected but are not yet available.

Table 1. The status in zoological collections of selected species of artiodactyls as reported to the *International zoo yearbook* census of rare animals in captivity. The census is taken each year on 1st January. The first group of figures shown for each entry indicates the total number of ♂♂♀♀ unknown sex reported; the figures in parenthesis indicate those which were reported as being bred in captivity; the figure below the line is the number of reporting collections.

mortality is high, the captive-born population has slowly but steadily grown. Apart from some wild-caught specimens in Santiago Zoo, Chile, the figures in Table 1 include only the specimens held in European zoos. These animals have recently been augmented by a reasonably substantial importation into North America. The indications are that given proper husbandry and housing the species has the capability of becoming well established in time. The studbook was taken over in 1979 by Antwerp Zoo and the prospect of controlled and planned distribution of the breeding population offers further hope for the future.

The brockets present a less encouraging picture. None is listed as threatened by IUCN and the group is not included in the *Yearbook* rare animal census, but our survey indicated that captive populations are far from well established. Most of the Red brockets *Mazama americana* in Europe are of Central and South American origin. Those in North America are the Mexican subspecies *M. a. temama*. They have been brought into captivity in sufficient numbers for breeding groups to be formed and the reports look encouraging: in 1965 one young was born in one collection; by 1971 six were born in three collections; by 1977 25 were born in 11 collections, and they continued to be produced in similar numbers in slightly fewer collections, mainly in the Americas, in more recent years. The progression looks fair, but there are two points to note: the neonatal mortality is high (eight of the 1977 young failed to survive) and the records for 1976–1978 show that a large number of births were to wild-caught ♀♀. While it seems that the Red brocket has a reasonable breeding potential, it is far from established in North America and there has been no record of breeding in Europe for the last few years.

The Brown brocket *Mazama gouazoubira* presents an even more dismal picture. Most of those in Europe are from South America and the few in North America are of the subspecies *M. g. pandora* from Yucatan. The animals in the West Berlin and Krefeld zoos breed regularly but mortality is high and the groups are barely being maintained.

The history of the Yucatan group is particularly sad. Originally 2.2 animals were acquired by Brownsville (Thomas, 1975) and for a time their reproductive rate was satisfactory. A 'surplus' pair sent to Los Angeles produced second generation young but only ♀♀ survived and breeding was at an end when the adult ♂ died. Meanwhile at Brownsville all except one ♂ had succumbed to stress and disease. The remnants of the two groups were put together in an attempt to retrieve the situation but when the Brownsville ♂ died, the Yucatan group in North America was represented by only three ♀♀ and no mate has become available to join them.

OKAPI

The founding population of the Okapi *Okapia johnstoni* was less than 50 animals. In 1962 there were 20.19 specimens in the *Yearbook* census, of which 5.2 were zoo born, in 16 collections. By 1981 23.28 specimens in 12 zoos were reported to the *Yearbook* (Table 1) while 27.34 animals, most of which are captive bred, were registered in the studbook. The group has been sustained in captivity over a long period of time with few wild-caught additions but it has just barely held its own. Studies by Foose (1978) demonstrated cause for concern and at the third captive breeding conference grave fears were expressed for the future of the species (Foose, 1980; Van Dam & de Boer, 1980). With the greater co-operation amongst zoos and the Species Survival Program developed in the United States, however, it is hoped that the future might be brighter. On the negative side, the species has a slow rate of reproduction, more ♂♂ are born than ♀♀, and mortality rate has paralleled survival rate. It is difficult to pinpoint any particular cause for the high death rate; there have been complications during birth, and other reproductive problems, as well as a toll from bacterial and mycotic infections. On the positive side, the Okapi is a fairly sturdy animal with a calm temperament and is not too difficult to manage. It is long lived and it is not uncommon for individuals to reach the high teens or early twenties in age.

PRONGHORN

The Pronghorn *Antilocapra americana* is found in the high plateau areas of western North America from Canada to Mexico. Although this unique species is not listed as threatened, it is comparatively rare in captivity even in the United States and Canada and, apart from one successful group at Pretoria, very few specimens are kept outside North America.

The Pronghorn has a long history in captivity, but it has proved to be a frustrating species with which to work. Although the animals are able to tolerate a wide range of temperature, their natural habitat is cold or scrub desert and they survive best in a dry climate; their record in collections situated in humid areas is poor. They have a quick response flight reaction and great care has to be taken not to startle them. The young tend to be nervous even when the adult herd is composed of relatively calm hand-reared animals and young left with the mother are easily alarmed.

We have found that if we allow the dam to raise her fawns, we compound the problem of nervous animals when they are older, and if they are transported to another location the risk of fatalities is extremely high. Information obtained from other zoos indicates that this is a general finding.

For many years now all the young at Los Angeles have been hand-reared. Originally, fawns were removed shortly after birth and raised in the Children's Zoo. This proved unsatisfactory and young are now kept in the holding area of the Pronghorn exhibit and hand-reared out of contact with each other for at least the first three weeks. At three to four weeks of age they are put with other young and shortly afterwards introduced into the main herd. Using this method the survival rate is in excess of 80%; the animals remain manageable throughout adulthood and can be transported when necessary with minimal risk.

Although the ♀♀ are quite gregarious and it is not uncommon to see herds of 40–50 in the wild, ♂♂ are often solitary. In captivity, it is necessary to reduce the number of ♂♂ in the herd to no more than one or two during

the breeding season or competitive agnostic encounters can cause injuries and stress.

Pronghorn were once recorded in as many as 21 collections but this was not sustained. At present, while the size of the overall population is increasing, the number of zoos holding them is on the decline (Table 1). The most consistently successful keepers, Albuquerque, Denver, Los Angeles, and, more recently, Abilene are all situated in dry climates. San Antonio also had a good record in the past but no longer keeps them.

SPIRAL-HORNED ANTELOPE

The spiral-horned antelopes are represented by medium-sized to large spectacular specimens, most of which are considered highly desirable in zoo collections. They tend to be shy secretive animals whose natural habitat is either dense forest or fairly thick open brush country. Of those covered in the survey five species have been reasonably successful in captivity and two have never been established in any great numbers.

Breeding in substantial numbers are the Nyala *Tragelaphus angasi* (Table 1), the Sitatunga *T. spekei*, Greater kudu *T. strepsiceros*; well established but less widely distributed and bred are the Bushbuck *T. scriptus* and the Bongo *T. euryceros* (Table 1). Substantial numbers have been imported and all these species generally adjust well to a captive environment, in some cases becoming quite docile. The replacement rate seems to compensate for infant and adult mortality. Of the five the most difficult to manage is the Bushbuck which tends to be nervous and easily startled. In 1977 30 births were reported in 13 zoos. More recently seven of the same zoos are still reporting breeding, three of the original zoos no longer breed the species, and the remaining three African zoos no longer supply data.

When at Brownsville Thomas found that Bushbuck were relatively easy to handle if hand-reared ♀♀ were allowed to rear their ♀ fawns and additional bottle feeds were given. It was always advisable to hand-rear the ♂♂, however, or they could become highly excitable and overstressed. It was also found that hand-rearing was necessary to achieve a

reasonable success rate when the animals were to be transported later; the mortality rate of mother-reared animals during transport was sometimes as high as 80%.

The most surprising and gratifying of this group to work with has been the Bongo. We had expected it to be similar to the Bushbuck in temperament but in reality, the individuals with which we worked more closely resembled the Greater kudu. We found them to be relatively tractable and the survival rate has been high. By 1984 the Los Angeles group had produced 34 births with only two deaths, one of which was the offspring of a ♀ pregnant when transported from the wild. This young had a number of congenital defects and survived only a few hours but the mother has since produced and reared a number of normal calves. Some zoos have reported difficulty with aggressive ♂♂ which have had to be kept separately from the ♀♀ and were a danger to their keepers. The ♂♂ at Los Angeles, however, are docile both with keepers and with other Bongo (Udell, 1984).

At this time the Nyala, Sitatunga, Greater kudu and Bongo appear to be well established and provided the gene pool is sufficiently large they should, with proper management, be capable of maintaining self-sustaining populations.

The two species which have never been imported in any great numbers are the Lesser kudu *Tragelaphus imberbis* and the Giant eland *Taurotragus derbianus*. The Lesser kudu showed little increase for many years. Throughout the 1960's there were never more than four or five zoos, and often less, reporting usually a single birth each. In the worst year, 1971, only one birth was recorded. After an influx of animals from the wild breeding increased during the early 1970's to reach a high of 32 young in six zoos in 1977. To date in the 1980's five zoos have reported breeding each year with a total of between 20–28 births and a neonatal mortality of between 15–42%. This is another highly nervous species where most of the deaths appear to have been stress related. Although in a few collections groups appear to have become established and survival rate is greater than mortality, of the 28 recorded

births in 1980 the majority were in just three zoos and in one of these there was a 40% neonatal mortality. There is some hope that we are reaching the point where they are being handled in such a fashion that there is promise for the future but this species still needs special consideration.

The most unfortunate species in this group is the Giant or Derby eland, which has rarely been exhibited (Table 1). A small number was imported into Chicago Brookfield Zoo in the late 1930's but all had died by 1946. Frankfurt imported one animal in 1958 which died the same year. Omaha imported a pair in 1968 but the ♂ died in 1970 and no mate was found for the ♀ which died some years later. One substantial importation was in 1968 when 3.8 animals from Chad were acquired by Antwerp Zoo. An additional 2.2 arrived in 1970. The group had begun to show great promise but an outbreak of tuberculosis caused heavy casualties and the last animal at Antwerp died in the early 1980's. This is a striking example of the problem which can arise when all the animals are concentrated at one location. The only survivors from the group were the descendants of 2.1 animals sent to Pretoria in 1973–1974. From this small start there were 14 surviving births and two stillborn young. Of the 14, four died later, two from stress-related causes. In 1981 the herd numbered 6.5 captive-bred animals but its numbers now appear to be decreasing.

CATTLE

The examples of wild cattle we considered are all forest dwellers. Although they tend to be shy and secretive in the wild, they adjust to captivity reasonably well. The Gaur *Bos gaurus*, the Banteng *B. javanicus* (Table 1) and the Congo or Dwarf buffalo *Synceros caffer nanus* have all shown reasonably good population growths. The Congo buffalo was originally imported into zoos in relatively small numbers but is bred regularly. There were 14.24 animals in ten collections registered with ISIS at the end of 1983 and there are at least five European zoos which are known to have bred them in recent years.

The Lowland anoa *Bubalus depressicornis* and the Mountain anoa *Bubalus quarlesi* were

regarded as subspecies of *B. depressicornis* until quite recently (Table 1). The IUCN *Red data book* lists both as Endangered in the wild. Their numbers have fluctuated slightly over the years. Although there is an increase in captive-bred animals the total population has not increased in the last decade and there is a skewed sex ratio with ♂ outnumbering ♀ births. Compared to other members of this group, neither form can be considered well established, and the Mountain anoa is held in particularly low numbers. The survival rate of the calves is high, however, and as the adults have a long reproductive life the prognosis may be good. The studbook has recently been re-instituted by Leipzig Zoo.

DUIKERS

Duikers are generally to be found in dense well-shaded vegetation. They are shy, retiring animals and many individuals are highly nervous, a fact which must be taken into account in captive management. They have a relatively rapid birth rate for ruminants, but they also have a fairly short life span. It is rare for a duiker to exceed 15 years of age and the majority die before the age of ten. Their requirements are highly specialised and have not always been catered for successfully. With a few exceptions they have not been imported in large numbers and the founder stocks were limited.

The best established are the Maxwell's duiker *Cephalophus maxwelli* and the Bay or Black-backed duiker *C. dorsalis*, which were imported in the greatest numbers and bred regularly, and the Yellow-backed duiker *C. sylvicultor* (Table 1). The Yellow-backed duiker was represented by only four specimens in one zoo in 1962 and by 32 (18.14) in 12 collections in 1981. The progress has been slow but steady, with the not uncommon tendency for more ♂♂ to survive than ♀♀.

The Red-flanked duiker *C. rufilatus* has always been fairly uncommon in captivity with limited numbers imported. Their best breeding year seems to have been 1975 when five young were born (only three survived) in four zoos. The species is now represented by a group of eight animals at Los Angeles.

Another rarely held form is the Zebra or

Banded duiker *C. zebra*, a species which has proved to be difficult to establish and quite delicate to manage (Table 1). Never numerous and with a mortality rate which either equalled or exceeded the survival rate, their captive populations have often been in jeopardy, even in the three zoos which have held the most specimens. At the beginning of 1984 the known breeding population was held in two zoos, Los Angeles and Frankfurt, a total of 3.8 animals.

Certainly a study in barest survival is the Jentink's duiker *C. jentinki*, listed by IUCN as Endangered (Table 1). It has been recorded as breeding in only one zoo outside Africa and indeed it was not until 1969 that three animals were imported into the United States. The species is now represented by 1.2 animals at Brownsville; at the time of writing there is one ♀ in Europe which cannot be imported to join the group because of health restrictions and a further ♀ in quarantine. The future of the present captive population must be considered grave.

The Cephalophinae has never been a highly popular group in zoos. Its members are small, expensive and difficult to handle and most collections would rather use the exhibit space for larger less troublesome animals. They could probably have made a better showing if they could have been imported in greater numbers.

With the exception of the larger duikers, that is the Yellow-backed and Jentink's, the highest mortality is in the first months after birth. Deaths sometimes result from lack of maternal care, but more often from the susceptibility of the young to injury, nutritional deficiencies and bacterial causes. There are also two records of deaths of neonates from heat exhaustion after their mothers had left them in direct sunlight with air temperatures in the range of 27–32°C. In both cases by the time the young were discovered by keepers, they were too near death to be saved. In their natural habitat the amount of direct sunlight which reaches the duikers is quite small. It would appear that the animal's heat regulatory mechanism is poorly developed for several weeks at least and care must be taken to keep duikers with young in shaded areas.

There are two additional precautions which could spell the difference between success and failure. Since open barren areas tend to result in excessive stress to the highly nervous duikers, they should always be provided with a considerable amount of cover to give them a sense of security. Secondly, the temperament of the keeper is an important factor. When handling duikers it is necessary to show a calm sensitive approach keeping stress to a minimum (Farst *et al.*, 1980; Udell, 1981).

ANTELOPE

In the subfamily Hippotraginae we considered two contrasting groups: two forms of waterbuck and five well-established species of the large spectacular antelope.

The waterbucks are generally found in open brush country near water sources, rivers, swamps and lakes. The reedbucks *Redunca* spp have been exhibited sparingly and have never been brought into captivity in sufficient quantity to become well established. When given adequate management most of the genus *Kobus* seem to breed fairly freely in captivity.

Among the least well established are the Nile lechwe *Kobus megaceros* and the White-eared kob *K. kob leucotis*. The Nile lechwe has demonstrated a slow but steady improvement; the number of zoos holding them and the size of the herds have increased. When the data are analysed, however, we find that the collections fall into two extremes: those zoos which have done well have done very well; those which have failed have failed dismally. There appears to be little difference in the facilities, general management, husbandry or breeding management such as introduction or other varying factors; yet while some zoos report good reproduction and survivability with few problems, others fail to produce surviving young even when unrelated animals have been brought in to improve the genetic diversity of the stock. The missing factor has yet to be determined but, setting aside the problems of individual zoos, the overall picture is good.

To our knowledge there has been only one importation of the White-eared kob into the

United States since World War II, a group of 1.4 animals. The ♂ was not in full colour but was sexually mature. Reproduction and survivability was good but eventually the group was unsuccessful because of a failure to control the aggression of the ♂♂. Even though their living area was large and allowed them considerable space to avoid each other, the arrangements for feeding and housing put the ♀♀ at a constant disadvantage. The majority of the deaths were due to injury inflicted on the ♀♀ by the ♂♂ and other problems could be attributed to the stressful situation. With hindsight it can be said that the history of this group is one of failed management. Even though exhibiting these animals in a herd may be very attractive for the general public, it is essential to separate them for feeding and to take steps to minimise the level of aggression of the ♂♂ towards the ♀♀ and calves.

Of the five species of large antelope mentioned above, three, the Scimitar-horned oryx *Oryx dammah*, the Arabian oryx *O. leucoryx* and the Addax *Addax nasomaculatus* (Table 1) are listed in the *Red data book*. They are animals of the open desert while the remaining two, the Roan antelope *Hippotragus equinus* (Table 1) and the Sable antelope *H. niger*, are found in small groups in open brush country. In captivity the last two species tend to thrive better in large enclosures and the larger herds have a proportionately higher survival rate. The entire group is characterised by tough and reasonably adaptable animals which have lent themselves to a captive environment extremely well. They need the minimum amount of management, although care must be taken to control their natural belligerency. They have been kept successfully in cold and hot climates and been found to do well in a number of different situations. Most zoos that have kept them have been fairly successful and, with the exception of the Arabian oryx, sufficient numbers came into captivity to establish fairly broad-based gene pools.

The Arabian oryx had an extremely small founder population but its numbers have increased markedly. From near extinction the captive population has grown to the point

where captive-bred animals have been reintroduced into the wild (see Stanley Price, this volume). The World Herd at Phoenix was begun with 4.5 animals which produced 129 young with only three stillbirths and 17 neonatal deaths within one month of age. At Los Angeles we started with a pair and their single offspring born in quarantine to which a pair from the World Herd was added later. From this base of four founder adults, we have bred over 70 animals with only three stillbirths and 11 which failed to survive to one month.

This is one of the most successful groups of ungulates in captivity. Their overall numbers are quite good and the distribution is widespread. There is no reason why the group as a whole cannot look forward to a very secure future.

The hartebeests and gnus, the remaining members of this subfamily, are plains or veldt dwellers. We looked at four species all of which are normally found in small groups of 25-30 animals.

The White-tailed gnu or Black wildebeest *Connochaetes gnou* was a victim of unrestricted hunting during the European settlement of South Africa and was classified as Endangered in the wild until the mid-1970's when as a result of public and private protection its numbers increased substantially. Where it has been well managed and given sufficient space, especially for the ♀♀ to avoid the ♂♂, its history in captivity has been good.

The Cape or Selbourne's hartebeest *Alcelaphus buselaphus caama* was probably brought into captivity in fairly small numbers but it is breeding in most of the zoos where it is known to be held and 71% of the stock registered with ISIS at the end of 1983 is captive bred. It is also breeding regularly in some European zoos and at Pretoria.

Numbers of the Bontebok *Damaliscus d. dorcas* also appear to have increased satisfactorily once it was established (Table 1). This species was also in danger in the wild but made a recovery once strict protection measures were in force. Although they are aggressive and therefore difficult to manage, their reproduction and survivability rate has been good.

The Hunter's antelope *D. hunteri* is listed as Rare in the wild. It has been imported into captivity twice only: one group to Dvur Kralove and the other to the United States. After an initially slow start the population began to grow well. Its position in three zoos in the USA is not unencouraging but the Czechoslovakian population which was expanding has recently disappeared from the records (Table 1).

With this entire group it is necessary to understand the family dynamics and to appreciate that the system of dominance is very rigid. The animals must either be given sufficient room to be able to escape from each other or sight barriers must be provided in the enclosure. There should also be facilities to separate them. They are all aggressive and need to be managed carefully. Bontebok in particular can be extremely rough in their treatment of ♀♀.

In contrast the smaller African antelope represent some of the more difficult animals to keep in captivity. The Klipspringer *Oreotragus oreotragus*, the Oribi *Ourebia ourebi* and the Suni *Neotragus moschatus* (Table 1) are found in arid brush country; the Oribi and Suni in heavy brush and the Klipspringer nearly always on rocky outcroppings and kopjes. All are shy and retiring and certainly inclined to be nervous.

The Suni and Kirk's dik-dik *Madoqua kirkii* are the only two species in this group which can be said to have adjusted and to have bred reasonably regularly, although neither is really well established. The first recorded Suni births were at Dallas in 1967. Births have occurred at Dallas each year since then and for a few years, between 1969 and 1974, at Tampa. Until 1978 these two were the only zoos outside Africa to report the breeding of Suni. In the last few years the picture has changed slightly. In 1981 five of the six collections in the USA which keep Suni bred them giving a total of 18 births. Only eight of these survived, however, and it is noticeable that in the longstanding and prolific Dallas group the neonatal mortality appears to be rising, although the number born each year has also increased. As there have been several imports over the years, the

present situation is far from satisfactory. Apart from a group in Kenya on which data are not always available, there are no known captive populations outside the United States.

The Oribi has been imported in small numbers but certainly these have been equal to those of Kirk's dik-dik and the Suni. The population reached a high in 1968 with 23.14 in 13 collections but recently their numbers seem to have been declining. A severe toll from bacterial infection and stress has been reported, a clear indication that in the management of these animals we are far from understanding and dealing with their problems.

The history of the Klipspringer has followed a similar pattern. Imported in reasonable numbers, they reproduced, apparently flourished and then suffered a rapid collapse. From 1966 to the late 1970's the situation appeared to be encouraging. In the last few years the overall population declined and they have been held in fewer collections. Most of those now in captivity are captive bred. In the United States the history of the Klipspringers has been even more dismal than in Europe. Only at Dallas has a small sustained reproduction been achieved.

It is obvious that this group needs considerable attention and study if we are to succeed in establishing it in captivity. The overall indication is that we are not meeting the needs of the animals and the stress induced mortality is equal to or greater than the survival rate.

In the gazelle group we looked at five forms of the genus *Gazella* and the related Gerenuk *Litocranius walleri*. All gazelle species are small to medium-sized and delicately built. They inhabit semi-arid or arid regions in the wild, living in small to medium herds with one adult ♂. Although they tend to be nervous and easily panicked, they can be kept reasonably successfully in captivity, especially where the founding group is sufficiently large.

The Gerenuk is probably the least well established. It was never held in any great numbers until the late 1970's and early 1980 when there was an influx of new animals

(Table 1). Little headway had been made in establishing the species before this time and the present captive population is founded mainly on the recent importations. The general pattern in the zoos which are major holders of stock is fairly similar. The founding stock consisted of 2.3 to 2.4 animals and in each case their reproduction rate has been good and the survival rate fair. At present there is a slow increase with the survival rate slightly higher than the death rate. Gerenuks require careful management and delicate handling. They are highly susceptible to bacterial infections and because of their nervousness and automatic flight reaction, death or injury to an animal which has crashed into a barrier is not unknown even in adapted herds of long standing. Despite the slow progress, however, we would guardedly regard their future as promising.

Of the five *Gazella* species three, the Dama gazelle *G. dama*, the Arabian gazelle *G. gazella arabica* (Table 1) and the Goitred or Persian gazelle *G. subgutturosa*, all came into captivity in reasonably good numbers. They have progressed well and the Dama gazelle, having proved to be one of the easier species to care for, has become extremely well adjusted to a captive environment. The only Endangered subspecies *G. d. mhorr* is held in very low numbers but the captive population is growing.

Even with a small founder population with proper care and attention gazelles can do surprisingly well, as evidenced by the Slender-horned gazelle *G. leptoceros* and Speke's gazelle *G. spekei*, both of which are Endangered (Table 1). The known captive animals are all in the United States. Only a few Speke's gazelle have been imported and the present population is based on a very small gene pool. Nevertheless it has been built up at Brownsville and St Louis (Read & Fruch, 1980) and small groups are being set up elsewhere. The Slender-horned gazelle has a similar history; imported in low numbers, at one time it was barely holding its own with a tiny population distributed among five collections. With the survivors in two very productive herds at New York Bronx and San Diego substantial progress was made. At the

time that this survey was undertaken there were fears that the lack of dispersion could constitute a danger, but more recently they have been split into separate groups and some transported to other institutions.

GOATS AND THEIR ALLIES

The Saiga *Saiga tatarica* is a member of the subfamily Caprinae but distinctive enough to be placed with the Chiru *Pantholops hodgsoni* in the tribe Saigini. It is a dweller of the great steppes of Central Asia and is an excellent grazer. They are social animals and are sometimes observed in fairly large groups, although the usual grouping is one adult ♂ with 12–14 ♀♀.

The behaviour of the ♂ at each reproductive cycle appears to leave the species on the brink of disaster. During the breeding season ♂♂ are extremely belligerent and for a time they eat and drink little, all their energies being devoted to fighting and mating. Since this occurs just as bitter winter weather begins, breeding ♂♂ are greatly weakened and only a small percentage survives to the following spring. It is upon this group that the next cycle of breeding depends.

In captivity it follows that ♂♂ are extremely aggressive but this problem seems to have been addressed, monitored and controlled in recent years. The animals also thrive better in cold dry climates. Hot humid weather usually results in their demise from bacterial and mycotic infections. For many years their performance in captivity was poor; although breeding occurred, the animals were lost and the groups died out (Dolan, 1977), but recently it has been shown that they can do reasonably well. The census figure for 1962 was 4.7 wild-caught animals in five zoos. By 1982 there were 37.67.15 animals in ten zoos, of which 21.34.15 were zoo born, and the rise seems to be continuing (Table 1).

Of the two species of serow only the Japanese serow *Capricornis c. crispus* is held in any numbers (Table 1). In Japan the captive population has done well. The census for 1962 shows just three animals in one zoo but that year also saw the start of the collection of animals at the Japan Serow Centre at Mount Gozaisho. Other groups were set up at a

number of other institutions between 1956–1970 and in 1964 the first Japanese serow to be conceived and born in captivity was recorded at Mount Gozaisho (Komori, 1975). By the end of 1981 the total population registered in the studbook consisted of over 100 animals, about half of them captive bred, in 28 collections. Outside Japan little has been achieved so far. The first pair to be exported, to Beijing (Peking), have bred successfully but, although captive-bred animals sent to San Diego and Los Angeles have produced young, these have failed to survive. The animals do not mature until they are nearly five years old, however, and more success might be hoped for when these pairs are older.

The Rocky mountain goat *Oreamnos americanus* has also been a problem species. Although the census figures (Table 1) show a steady rise and most are now presumed to have been captive bred, the mortality rate has always been high. The major causes have been a high susceptibility to bacterial and mycotic infections and parasite infestations. They need to be maintained in dry sunny conditions with very careful veterinary attention.

With the exception of the few native forms kept in Chinese zoos, the captive population of takins is represented by the Mishmi takin *Budorcas t. taxicolor* of Burma. The numbers in captivity have barely been maintained over the years. Reproduction is slow and mortality high and once again there is a preponderance of ♂ births. At this point, the problem of establishing this animal in captivity as a self-sustaining population is still far from solved (Table 1).

The Nilgiri tahr *Hemitragus hylocrius* has always been rare in captivity. Over the past 20 years there has been a slow but steady increase in the number of specimens and very recently in the number of locations. Mortality is high but the survival rate is slightly higher. The captive gene pool is small and if it were possible to introduce some new blood lines, it might go a long way towards increasing survivability.

We looked at four species of the genus *Capra* (Table 1). One point to be borne in

mind when comparing the *Yearbook* census figures both for this genus and the *Ovis* spp is that over the years the taxonomy used has changed and the figures for earlier years may include specimens which are now assigned to a subspecies.

All the *Capra* species mentioned are found in rough, rocky, mountain habitat usually in fairly arid conditions. Whenever they have been held in sufficient numbers and subjected to a reasonable standard of husbandry, their history in captivity seems to be quite good. Certain problems are general. As with many alpine forms, they tend to be parasite prone and are best housed in open sunny enclosures that tend to be dry. Where they have done poorly in the past, they have been kept in areas of deep shade and high humidity. Overall their reproduction and survivability are exceptionally good. The survey revealed reasonably well-established groups which appear to be self-sustaining.

The census figures for the Bezoar or Wild goat *C. aegagrus* taken as a whole, indicate that the population has expanded little over the years. Some 17 to 18 zoo-born animals released into the wild in New Mexico in 1968, however, have flourished and now number over 1000. The Cretan subspecies *C. a. cretica*, which was originally imported into San Diego as a single pair sometime before 1970, is also accounting for a larger proportion of the total captive population. In 1981 two San Diego collections contained 27 captive-bred specimens but the numbers have fallen recently. There are a few in Europe but the largest herds are at the Hai-Bar Reserves in Israel. The other subspecies known to be held in captivity, the Pasang *C. a. blythi*, is held only in the USSR.

The *C. ibex* and *C. falconeri* subspecies show a similar pattern of successful increase, although the number of zoos reporting on them tends to be fairly constant.

Any assessment of the *C. caucasica* (= *severtzovi*) population over the two decades is confused by the several changes in taxonomy adopted in the *Yearbook* census. Originally recorded under two separate headings as *C. ibex severtzovi* and *C. caucasica*, the two groups were later combined as a sub-

species *C. i. caucasica* (= *severtzovi*) and are now considered as belonging to one full species, *C. caucasica* (= *severtzovi*). Also, when the census figures for 1970 (volume 11) are compared with those of the following year, it is clear that many of the animals in the USSR and Czechoslovakia shown in the earlier volume as *C. i. caucasica* had been reassigned to a subspecies not previously listed, the East Caucasian tur *C. i. cylindricornis* (now shown as a full species). When the census figures are tabulated, they appear to have fluctuated more than is actually the case. Overall the populations have probably been fairly constant, but with an increasing proportion of the whole being captive bred.

SHEEP

The Bharal or Blue sheep *Pseudois nayaur* has barely survived in captivity outside its native China. The *Yearbook* census figures for recent years include the animals in Beijing but no other Chinese zoos (Table 1). Elsewhere there have been few imports and the death rate is almost equal to the birth rate. The longest surviving group is in Paris. Despite the lack of success so far, however, the animals are fairly long-lived and a sufficiently broad-based founder group could be extremely effective. The recent arrival of 4.4 animals at San Diego could offer great hope for a future captive population.

Although closely related to the goats, sheep have been more difficult to adapt. The *Ovis* species shown in Table 1 are fairly well established but they are not without problems. Considering the small numbers brought into captivity the Elburz red sheep *O. orientalis* and the Afghanistan/Iranian urial *O. o. cycloceros* have adapted reasonably well. The figures in Table 1 for the American bighorn *O. canadensis* (which includes the California bighorn *O. c. californiana*) and the Dall sheep *O. dalli* indicate that they are flourishing and the Stone sheep *O. d. stonei* appears to be making a steady improvement. The other *O. canadensis* subspecies listed, the Desert bighorn *O. c. nelsoni*, has not always been recorded separately but it appears to be in captivity in extremely low numbers and some outbreeding is urgently needed.

The day-to-day maintenance of sheep is relatively easy but they have a large number of medical problems and are highly susceptible to bacterial and mycotic infections. It is necessary to monitor them constantly if a good standard of health is to be maintained. This is particularly true of the North American forms where lungworm has been a great problem. Here the captive situation parallels the wild where Bighorn sheep have been found to be severely infected by lungworm after contact with domestic sheep. Asiatic sheep show considerably more resistance to bacterial and parasitic infections.

VETERINARY CARE

The survey demonstrated that basic veterinary care is extremely varied but it is abundantly clear that it is important to institute strong preventative medicine and vaccination programmes. All the zoos replying to our questionnaire reported taking some precautions. We believe the regime currently in use at Los Angeles, which we summarise below, is as comprehensive as any reported to us.

1. *Vaccinations/Neonates* At one or two days post partum all artiodactyls are vaccinated against the following: tetanus (Tetanus Toxoid); clostridial enteritis (Fermicon-7); bovine rotavirus and coronavirus (Calf-Guard); and rabies (Imrab). Depending on availability a killed bovine viral diarrhoea vaccine is also given.

In addition duiker and giraffe neonates are vaccinated against the Venezuelan, eastern and western forms of equine encephalitis (Cephalovac VEW). Pronghorn and Gerenuk receive a monoclonal antibody against *E. coli* (Genecol) to prevent coliform calf scours. For preference this should be administered within 12 hours post partum.

All neonate ungulates receive injectable vitamin E and a long-acting penicillin combination.

2. *Vaccinations/Adults* On an individual basis as the opportunity arises all artiodactyls receive: Tetanus Toxoid; polyvalent clostridial enteritis vaccine; killed rabies vaccine;

killed bovine viral diarrhoea vaccine when available.

Adult duikers, giraffes and perissodactyls also receive the trivalent equine encephalitis vaccine.

3. *Parasite control* Faecal samples are examined periodically. Generally strongyles are present and Bighorn sheep and Chamois *Rupicapra rupicapra* are usually infested with *Capillaria* as well. Lungworm infestations, regularly found in Dall's sheep, are controlled by cambendazole (Camvet). Coccidiosis is frequently found in the Chamois, Nubian ibex, Markhor, Gerenuk and Arabian oryx herds, although little or no clinical effect is observed. It is a problem in Dall's sheep where it does not respond well to treatment. All animals found to be infected with coccidia are treated with Vetasulid or Bactrovet. At one time ESB-3 was used but is no longer available.

SUMMARY

In assessing the situation revealed by the survey, we concluded that in general when sufficient numbers of founders were available and attention paid to the animals' general and specific needs, including preventative medicine, the captive populations have done reasonably well.

It is obvious that some small groups, such as the small African antelope and the duikers, need highly specialised care and there is a great deal of work still to be done on their husbandry.

The mountain or alpine species have been fairly successful with the goats showing the greatest adaptability. We feel there are grounds for optimism for the future of such animals as the Rocky mountain goat, the Japanese serow and even the Blue sheep.

Of those species whose captive future is still in doubt, particularly those which are threatened in the wild, our researches indicate that concentrated efforts should be made to obtain sufficient founder stock to establish self-sustaining populations as a hedge against total disaster in the wild. We felt that the evidence was strong that any of the ungulate

species reviewed could be successfully maintained in captivity given the right circumstances.

Basically, the husbandry procedures of all the reporting zoos were similar, although, of course, each zoo had its own variations. In some cases these measurably affected the success of the animal population. In the last 20 to 25 years inter-zoo co-operation and sharing of information has greatly expanded. Nevertheless we would now urge that even more emphasis should be put on the exchange of information to provide each zoo with up-to-date data which would ensure that all zoos are kept abreast with the 'state of the art'. With such a spirit of co-operation the prospect of managing species as total captive populations appears to be practical and promising.

ACKNOWLEDGEMENTS

The survey on which this report was based was a demanding one and we are indebted to the staff of the institutions listed in Appendix 2 who put in the immense amount of effort to complete and return the questionnaires. The veterinary data were compiled by Benjamin Gonzales, DVM of Los Angeles Zoo.

PRODUCTS MENTIONED IN THE TEXT

Bactrovet: sulphadimethoxine antibiotic, manufactured by Pitman-Moore Inc., Washington Crossing, NJ, USA.
Calf-guard: bovine rota-coronavirus vaccine, manufactured by Norden Laboratories, Lincoln, NE, USA.
Camvet: cambendazole antibiotic, manufactured by Merck Animal Health Division, Rahway, NJ, USA.
Cephalovac VEW: trivalent equine encephalitis vaccine, manufactured by Jensen-Salsbery Laboratories, Kansas City, MO, USA.
Fermicon-7: polyvalent clostridial enteritis vaccine, manufactured by Bio-Ceutic Laboratories, Inc, St Joseph, MO, USA.
Genecol: *E. coli* monoclonal antibody, manufactured by Molecular Genetics, Minneapolis, MN, USA.
Imrab: killed rabies vaccine, manufactured by Pitman-Moore Inc., Washington Crossing, NJ, USA.
Tetanus Toxoid: tetanus vaccine, manufactured by I. S. V. T. Sclavo, Siena, Italy.
Vetasulid: sodium sulphachlorpyridazine antibiotic, manufactured by E. R. Squibb & Sons, Princeton, NJ, USA.

REFERENCES

DOLAN, J. M. (1977): The saiga *Saiga tatarica*: a review as a model for the management of endangered species. *Int. Zoo Yb.* 17: 25-32.
 FARST, D. D., THOMPSON, D. P., STONES, G. A., BURCHFIELD, P. M. & HUGHES, M. L. (1980): Maintenance and breeding

of duikers *Cephalophus* spp at Gladys Porter Zoo, Brownsville. *Int. Zoo Yb.* 20: 93-99.
 FOOSE, T. J. (1978): Demographic and genetic models and management for the okapi (*Okapia johnstoni*) in captivity. *Acta zool. path. antwerp.* 73: 119-195.
 FOOSE, T. J. (1980): Demographic management of endangered species in captivity. *Int. Zoo Yb.* 20: 154-166.
 GOODWIN, H. A. & HOLLOWAY, C. W. (1978): *Red data book. 1. Mammalia*. Morges: IUCN.
 KOMORI, A. (1975): Review of the Japanese serows *Capricornis crispus* in captivity. *J. Jap. Assn zool. Gdns Aquar.* 17: 46-51. [In Japanese].
 READ, B. & FRUEH, R. J. (1980): Management and breeding of Speke's gazelle *Gazella spekei* at the St Louis zoo with a note on artificial insemination. *Int. Zoo Yb.* 20: 99-104.
 THOMAS, W. D. (1975): Observations on captive brockets *Mazama americana* and *M. gouazoubira*. *Int. Zoo Yb.* 15: 77-78.
 THORNBACK, J. & JENKINS, M. (1982): *The IUCN mammal red data book. Part 1*. Gland: IUCN.
 UDELL, C. C. (1981): Breeding the zebra duiker *Cephalophus zebra* at the Los Angeles zoo. *Int. Zoo Yb.* 21: 155-158.
 UDELL, C. C. (1984): Husbandry, breeding and behaviour of bongo *Tragelaphus eurycerus* at the Los Angeles Zoo. *Int. Zoo Yb.* 23: 237-242.
 VAN DAM, D. & DE BOER, L. E. M. (1980): Endangered species and breeding consortia. *Int. Zoo Yb.* 20: 177-179.

APPENDIX 1

QUESTIONNAIRE — SURVEY OF RARE RUMINANTS IN CAPTIVITY

1. Common name
2. Genus:
 - Species:
 - Subspecies, if known:
3. Statistics:
 - A. Number and sex of original animals
 - Source, and date of acquisition
 - Age on arrival
 - B. Number and sex of additional animals
 - Source, and age on arrival
 - C. Number of births, etc.:
 1. Live viable births surviving 1 month
 2. Live viable births surviving less than 1 month
 3. Stillborn
 4. Abortions
 - D. Number and cause of deaths:
 1. Bacterial
 2. Mycotic
 3. Viral
 4. Trauma
 5. Other
 - E. Age of parents at first birth:
 - Age of animals at first observed breeding:
 - Estimated gestation:
 - F. Longevity:
 1. Maximum
 2. Average

4. Diet (including supplements):
 - Where fed:
 1. Indoor Outdoor
 - Number of sites:
 2. Common location Multiple location
5. Preventive medicine:
 - A. Immunisation regimen:
 - B. Ecto and endoparasite problems and treatment:
6. Husbandry:
 - A. Size of indoor exhibit and/or holding area:
 - B. Size of outdoor exhibit and/or holding area:
 - C. Number of animals and sex ratio maintained in these areas:
 - D. Are the males and females kept with the group continuously:
 - If separated, when:
 1. At night, security/lockup:
 2. Maternity—if females isolated at birth, when is male reintroduced to female and calf:
 3. Put together for breeding only:
 - E. Are other mammals or birds kept in the same enclosure:
 - If so, what species and numbers:
 - Have there been any problems:
 - F. Can young be left with the herd:
 - If so, how long:
 - G. Formula used for hand-reared animals, if any:
7. REMARKS:

PLEASE RETURN COMPLETED SURVEY BY JULY 1 1984 TO:

WARREN D. THOMAS, DVM
DIRECTOR, LOS ANGELES ZOO
5333 ZOO DRIVE
LOS ANGELES, CALIFORNIA 90027
U.S.A.

APPENDIX 2

Replies were received from the following zoos:

Abilene USA; Abu Dhabi UAE; Albuquerque USA; Amsterdam Netherlands; Baltimore USA; Basle Switzerland; Berne Switzerland; Boston USA; Bristol Great Britain; Brownsville USA; Calgary Canada; Catskill USA; Chester Great Britain; Christchurch New Zealand; Cincinnati USA; Cleveland USA; Cologne W Germany; Copenhagen Denmark; Denver USA; Detroit USA; Dortmund W Germany; Edinburgh Great Britain; Gelsenkirchen W Germany; Hanover W Germany; Indianapolis USA; Jacksonville USA; Johannesburg South Africa; Krefeld W Germany; London ZSL Great Britain; Louisville USA; Memphis USA; Minnesota USA; Mulhouse France; Nagoya Japan; Philadelphia USA; Phoenix USA; Prague Czechoslovakia; Pretoria South Africa; Sacramento USA; Salt Lake City USA; San Diego USA; San Francisco USA; St Louis USA; Surabaya Indonesia; Toronto Canada; Whippsnade Great Britain; Winnipeg Canada; Wuppertal W Germany; Zurich Switzerland.

Int. Zoo Yb. (1986) 24/25: 99–106

Endangered small mammals in zoos

BRIAN C. R. BERTRAM

Curator of Mammals, The Zoological Society of London, Regent's Park, London NW1 4RY, Great Britain

A small mammal house is often tacked onto a zoological garden almost as an optional extra. Larger animals, especially large mammals, tend to get the lion's share of public attention, keepers' time and zoos' resources. Yet as with many of the even smaller animals, small mammals have their share of endangered species, to whose continued survival zoos may be able to contribute.

In this paper I assess the extent of the attention which threatened small mammals receive in zoos compared with that given to larger mammals, outline the few successful captive breeding programmes for particular

threatened species of small mammals, and discuss where we should be going in order to improve the situation.

STATUS OF SMALL MAMMALS IN CAPTIVITY

In order to assess size effects in relation to 'endangeredness' and captive breeding, I have subdivided the mammals on the basis of head-and-body length. The data have been taken from *Walker's mammals of the world* (Nowak & Paradiso, 1983). Body length rather than body weight was used because the measurements are more available; there are